Researching the Sustainability of Reform

BOLTON

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PROJECT OVERVIEW

The *Researching the Sustainability of Reform (RSR)* project focused on the question of how to maintain the gains of an initial educational change process and support continuing reform over time. Within the broader study of sustainability, the research paid particular attention to systemwide approaches to science education reform as well as to the role that external funds can play in initiating reforms that are sustained. The research was conducted by staff of the Center for Science Education at Education Development Center, Inc. (EDC), in Newton, Mass., in collaboration with staff at the Caltech Pre-College Science Initiative (CAPSI) in Pasadena, Calif. This research was supported by a grant from the National Science Foundation and was directed by Dr. Jeanne Rose Century at EDC and Dr. Jerome Pine at CAPSI.

The goal of this study was to identify and document factors in school systems that contribute to sustained educational change in science education. The purpose was to provide districts now engaged in improving their science education programs and districts that are considering doing so in the future with information to help them more strategically and effectively build an infrastructure for long-term improvement.

Specifically, this study focused on nine communities with K–6 science education programs begun from nearly 10 to 30 years ago. These communities differed in their sources of funding as well as the longevity of their programs. This study investigated how, and the extent to which, these communities have sustained their science education programs and the factors that have contributed to this sustainability.

Through on-site interviews and observations, surveys, case studies, and document analysis, the study investigated the districts' efforts in the following areas:

- Current status of the science program compared with initial goals
- System context and external conditions that have an impact on lasting change
- Strategies for achieving program goals and building district capacity to improve
- The influence of practitioner and system capacity on sustainability
- External funds as a catalyst for widespread, lasting reform

The findings of the research include nine descriptive site summaries and a cross-site report. The site summaries were designed primarily to provide the reader with a description of the origins, implementation, and evolution of each of the nine science programs. They also offer a brief analytic section that is designed to provide the reader with a bridge to the cross-site report. The cross-site report draws from all nine sites to identify common themes and recurring issues relevant to sustainability. It is primarily analytic while offering concrete supporting examples drawn from the nine sites. The cross-site report also includes a discussion of implications of the findings for funders, reformers, and practitioners.

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SUMMARY OF RESEARCH METHODOLOGY

Research Questions

The study was guided by the global research question: What factors contribute to or inhibit the sustainability of a districtwide hands-on science program? Within this broad question, the research focused on several sub-questions: (1) What is the current status of the science education program within the system and how does that compare with the initial goals and implementation of the program? (2) What conditions and contexts surrounding a science education reform effort impact the sustainability of the reform? (3) What decisions have practitioners made and what strategies have they used to bring about enduring change and build capacity for continuous growth? (4) How has the capacity of the practitioners in the system and the capacity of the system itself affected the sustainability of the reform? and (5) What is the role of external funds as a catalyst and/or support for lasting, widespread reform?

Research Design & Analysis

To answer these questions, the study utilized a multi-site case study methodology that made full use of primary and secondary data sources and accounted for the uniqueness of each community while allowing for cross-site generalizations. The primary data was gathered using qualitative approaches including semi-structured interviews, focus group interviews, observations, and document analysis. This data was supplemented with quantitative data collected through a survey administered to all principals and a random sample of 100 teachers at each site.

Some members of the research team had previous experience working with some sites. To alleviate bias, researchers gathered data in sites with which they had no prior interactions. Throughout the process of analyzing data, researchers were careful to address the potential of bias as a result of their experience with hands-on curriculum and any interactions with sites previous to this study.

Site Selection

The study focused on nine school districts[1] that have established an elementary science program reflecting the standards developed by the National Research Council and the American Association for the Advancement of Science. The districts fall into two main groups: those that began their science education reform efforts in the 1960s and early 1970s, and those that began their efforts from the mid-1980s into the 1990s. Four of the nine communities are in the former group. Of those four, two have had enduring science education programs and the other two had programs that were strong for a number of years, waned over time, and are currently in a process of renewal. These communities were of particular importance to the study as they shed light on the long-term development of science education programs and on how the "trajectories" of reform efforts vary over many years.

The remaining five communities fall into three sub-groups: Two had funds from the National Science Foundation that had been expended before the research began; one received funds from the National Science Foundation that were expended immediately prior to the beginning of the research; and two initiated their science reform efforts without significant external funding. Together, these districts represent a range of size and geographical location as well as years of participation in reform.

1 All district and individual names are pseudonyms.

Site Visits

Teams of two researchers made several site visits to each of the nine sites over two and one half years of data collection. Each site was visited at least three times with each visit lasting two to four days. In the initial phase of the research, researchers conducted "pre-visits" and phone interviews that enabled them to obtain an overview of the history of the site, discuss data collection procedures, and identify important issues and additional data sources/key individuals to interview. These pre-visits allowed researchers to construct a timeline of the science program, identify critical events in the life of the program, and identify major players both inside and outside the district. This initial contact also included discussions of logistical issues (e.g., timing for site visits), potential schools and classrooms to visit, and tentative scheduling of individuals to interview on-site.

Following the pre-visit, site visits typically consisted of interviews with key district personnel including the superintendent, assistant superintendent, assessment specialist, director of professional development, director of curriculum and instruction, budget manager, science coordinator, Title I and Federal Grants administrators, mathematics and language arts subject matter coordinators, technology program director, and special education director. In addition, researchers conducted teacher focus groups as well as interviews with key stakeholders, such as school board members, union representatives, and community members. Researchers also conducted a minimum of 20 observations of science instruction in at least 10 schools and conducted interviews with the teachers observed and their principals. Researchers also observed professional development sessions and reviewed documents on-site.

Interview and Observation Protocols[2]

Interview protocols were designed to gain information about the goals/vision of the district science program, actual classroom practice, professional development, support for teaching science, sustainability of the district science program, and other key critical issues that had an impact on the science program or the district. Interview protocols were adapted to the individual/group being interviewed. The interviews also explored the factors an individual thought contributed to sustainability of the science program, what factors supported or jeopardized the program, and what they envisioned for the future of the district's science program. Individuals were also given the opportunity to discuss any other issues that they thought were relevant that the interview had not explored.

Researchers conducted observations of science classes to gain a clearer understanding of the current status of the district science program. The objective of an observation was to obtain a "snapshot" of instruction, to contribute to a larger understanding of the school district's practices and goals, and to document the use of hands-on investigation and/or inquiry methods of teaching science. Researchers normally observed an entire science class in grades K–6 that varied in length from approximately 30 minutes to an hour depending on the lesson. Researchers used a semi-structured observation protocol to document the structure of the lesson and capture the teacher's instructional strategies.

Principal and Teacher Surveys

Researchers administered two surveys: the first to all principals in each of eight district sites and the second to a random sample of 100 teachers in each of the eight district sites[3]. The purpose of the surveys was to supplement the qualitative findings of the study by providing additional data on the current status of the program.

2 For a list of interviews and observations conducted at this site, see Appendix A.
3 One district, Montview, chose to abstain from participation in the survey.

These data may not accurately reflect actual districtwide practice. (For a summary of the survey data, see Appendix B.) Survey development followed a three-step process: (1) Researchers conducted a review of other similar instruments; (2) surveys were piloted and interviews were conducted with pilot participants; and (3) a survey expert reviewed the surveys and provided feedback so final revisions could be made.

The surveys provided corroboration of qualitative data and helped guide future qualitative data gathering. They were designed to answer the following questions: (1) What are the respondents' understandings of the current science program? (2) What importance do respondents place upon the science program and what priority does it get within the other areas? (3) What are the respondents doing to implement/support the science program? (4) What factors are important in sustaining an effective science program? The surveys included items about teacher/principal background and experience, school instructional practice, curriculum and materials, professional development, principal practice, teacher classroom practice, influences on science, support for science, and sustainability of science.

For more detailed information about the methodology of this project, please refer to the cross-site report.

OVERVIEW OF PROJECT SITES

	Glenwood*	Lakeville	Hudson††	Montview‡	Bayview	Garden City	Sycamore	Benton	Bolton
SIZE									
Sq. Miles	47†	76	200	800	55	800	25	15	320
# elem. students	27,000	12,000	43,151	47,087	5,849	28,000	6,400	4,300	27,000
# elem. schools	77	23	50	92	23	52	30	15	60
# elem. classroom teachers	1,300	778	1,630	1,978	600	1,300	300	200	1,144
RESOURCES									
Per pupil expenditure	5,668	4,996	5,122	4,443	5,973	5,046	6,500	13,296	6,508
Teacher starting salary	$31,172	$35,573	$27,686	$25,832	$27,467	$27,718	$29,892	$34,116	$32,600
NSF funds?	yes	yes	yes	no	no	no	no	yes	yes
DEMOGRAPHICS									
% students eligible for free and reduced price lunch	66%	70%	41%	18%	40%	32%	65%	39%	30%
% white	13	17	68	85	57	69	69	41	62
% African American	18	34	3	1	12	28	12	34	9
% Hispanic	21	45	23	11	10	0	11	14	6
% Asian/Pacific Islander	27 (Chinese)	4	2	3	18	0	8	10	9
% Native American	21	0	4	0	3	0	0	0	13
% Other	0	0	0	0	0	3	0	1	1
OTHER INFORMATION									
Year program began	1989	1986	1974	1968	1966	1989	1988	1994	1977

* District names are pseudonyms.
† Figures are for years ranging from 1998–2000. During this time demographics and expenditures shifted and were calculated in a variety of ways.
†† The Hudson site report offers the reader an additional detailed description of a classroom science lesson.
‡ The Montview site report is unique in that it emphasizes the historical development of the program and the circumstances that influenced and shaped its evolution.

BOLTON

EXECUTIVE SUMMARY

INTRODUCTION

The Bolton School District's (BSD)[1] hands-on, kit-based elementary science program was a pioneer in the field and has been a key feature of the academic program since the mid-1970s. At that time, Pearl North, a high school science teacher, introduced hands-on science to BSD and, over the course of several years, established a districtwide program. By 1996 the second generation of the program began, led by Dorothy Parson, a former "teacher expert" who reinvigorated it by redesigning the curriculum and expanding the program's depth and breadth. Unlike North, Parson had the assistance of a core team of teachers and a $3.1 million grant from the National Science Foundation (NSF) that targeted districtwide professional development for elementary science. The third and newest generation of the program currently is led by two teacher experts, Sophia Harder and Maria Clay, who took over in 2000. Both Harder and Clay were key players in the NSF grant and bring years of elementary classroom experience and knowledge of science education to the task of moving Bolton's program into the future. Their story and the story of BSD offer a lesson in program evolution and how each stage of historical development contributes to long-term program sustainability.

CONTEXT

Community Overview

Bolton, with a population of 225,000, is among the largest cities in its largely rural state and serves more than 40 percent of the state's children. In 1999, 60 elementary schools in Bolton served over 27,000 students, with 1,300 certified staff and 1,144 classroom teachers. There are 11 middle schools, 6 high schools, and 8 special program schools. Although the district encompasses the municipality of Bolton, which is more than 1,000 square miles, the primary populated area covers about 320 square miles. The remaining area is rural and sparsely populated.

The student population of BSD is moderately diverse. In the elementary grades alone (K–6), as of 1999–2000, white students composed 62 percent of the population, Native American students 13 percent, African American and Asian Pacific Islander each composed 9 percent, with Hispanic children accounting for 6 percent. In addition, nearly 11 percent of elementary students are learning English as their second language. Slightly more than 30

1 Any individual, organization, or corporation named in this report has been given a pseudonym.

percent of BSD elementary students are eligible for free and reduced-price lunch and several thousand students have special needs. Average student mobility over the past several years has remained steady at about 20 percent.

Issues of Local Importance

Testing and Standards: Academic testing and standards are lightning rod issues in Bolton as they are across the country. The state has implemented statewide testing in reading, writing, and math, along with exit exams to be given to grade 10 students, which they must pass to graduate. In addition, the state is considering a plan to issue school report cards, which will rate schools as distinguished, proficient, declining, or in crisis.

Local Culture: Bolton's population bears a subtle but significant characteristic that has made an impact on the science program. Many are drawn to the outdoors and are predisposed to understanding, protecting, and taking part in the natural world. The use and protection of natural resources is a compelling public issue. These factors suggest that there is a culture in Bolton already sympathetic to the importance of understanding the environment and teaching science.

PROGRAM HISTORY AND DEVELOPMENT

Program Origins

Pearl North was hired in 1974 to be BSD's second-ever science coordinator when the elementary science program was a "hodgepodge." She had a mandate from the former director of elementary education to create "one science program," and from the principals to "do something with all the science junk in the back closets!" North educated herself by attending many NSF-funded institutes to look at different approaches and eventually learned about a program in a nearby state. In 1974, she went there to talk to its director to learn more. "That was the turning point for Bolton," she recalls. Over the next several years, North modeled her work after the district she had visited and enlisted its director to visit Bolton and advise her and a committee of principals she had organized.

In 1975–76, using commercial kits as a model, North set out to develop kits tailored specifically to the BSD schools. She went to the elementary buildings and emptied their closets of old science resources and engaged BSD teachers and the environmental organizations of the community in the process of designing and creating the kits. North recalls her activities at the time as a whirlwind of activity all focused on getting kids' hands on the "stuff of science." North delivered the first batch of kits to seven volunteer schools in December 1977. Each of the school principals had committed to providing financial support for a shared "resource teacher" and an aide. Over the next two years, the program began to solidify. Use of kits expanded to 38 schools by the end of 1979, and by the very early 1980s, all elementary schools were using the kits on a voluntary basis. Then in 1981, the program passed a key landmark. The Elementary Science Curriculum Committee recommended to the school board that they eliminate the use of elementary science textbooks for the science materials adoption, and use kits exclusively. The school board agreed, and with that decision, the science kits became the official elementary science program for BSD.

In contrast to the previous upward trajectory, the mid-1980s brought a decline in the program. In 1985, the eight resource teachers that had been in place were reduced to four. Then, between 1986 and 1988, the superintendent, who was new to the district, cut many millions of dollars from the budget, which had a profound impact on the elementary science program. Staff and refurbishment supplies were cut, and the number of resource teachers was first reduced to three, then two, and then in 1988–89, eliminated altogether.

North and the materials center staff were left to manage the program on their own until fall of 1989. At this point, a year had passed without any support in science for elementary classroom teachers, and central office administrators recognized that it was time to attend to the diminished science program. Parson, the program's future leader, was hired as the district's "teacher expert." Also at that time, recognizing that it was due for an adoption of elementary science materials, the district allocated the elementary science adoption money to refurbish the newly revised kits and increase their number. A program revival had begun.

In 1991, Parson took a team of educators to the NEXT STEPS Conference in Washington, D.C.[2] and as a result, formed a core team of 24 teachers from across all grades. They began planning the curriculum. As the work progressed, Parson and her team revisited the kits they had in place, and based on the developing new framework, revised them and added new ones, including some that were now commercially available. Then in 1992, a grant from the U.S. Department of Education enabled the core team to complete the grade-level framework and thoroughly field-test the new kits.

In an attempt to obtain the funds necessary to fully implement the new curriculum as planned, Parson applied to NSF for a Local Systemic Change (LSC) grant. The proposal was funded, and when the field-testing was completed in 1995, $3.1 million in LSC funds enabled a massive, four-year training effort that would involve every elementary teacher each year. Full scale, mandatory training on the kits began in 1995–1996. Teachers also got support for monthly grade-level meetings. As a result of building teacher's content knowledge, teaching skills, and confidence, "Better teachers are teaching better science," the district's science coordinator observed.

2 NEXT STEPS was originally sponsored by the Association of Science Materials Centers and now is jointly run by ASMC and the National Science Resources Center (NSRC).

In 2000, as LSC funds wound down, Parson prepared to leave her position and the two strong "teacher experts," Sophia Harder and Maria Clay, stepped forward to take the reins. Their principal concern rested in making the transition from a large, time-limited, externally-funded project to an internally supported, institutionalized district science program. They, as well as teachers, principals, and administrators, were anxious about the void that would be left by the end of the LSC funding, and no one was sure how to fill it. Before Parson's departure, she reflected on sustainability, the LSC, and what she might have done differently. She observed that although she might handle the next phase of the program differently than Clay and Harder, the program was in good hands and it would (and should) develop in a way that reflects their unique styles and interests rather than her own.

THE CURRENT PROGRAM

Curriculum

The Global Community Science Program (GCSP), as it has become known, is the district's kit-based, elementary science program. Each classroom teacher is expected to use three kits (each covering one of three strands: life science, physical science, and earth science) per year with each kit lasting seven to eight weeks. A fourth strand, known as "Explorations in Science," is an opportunity for teachers to explore topics that respond to the particular interests of their classes and/or to a community issue.

The science materials center continues to enjoy strong support from the district. It is run out of the district's warehouse and now is quickly outgrowing the space. BSD has recently adopted a new computer-based inventory system, revamped the way vendor information and ordering procedures are managed, and developed a sophisticated ordering and distribution system to process teachers' spring kit rotation requests.

Instruction

In general, teachers express a desire for students to develop their natural curiosity and enthusiasm for doing science. One teacher commented, "I want them to experience science, and these kits allow them to do that," while another said she wanted "to encourage each child to participate and get their hands in it at this age." Another typical teacher comment—"I want the kids to pose their own questions for their own experiments and have the opportunity to test some things"—reflected a general interest in having their students understand the scientific process as well as particular science concepts. Finally, many teachers explained that they want to foster the joy of learning and exploration.

Teachers also discuss the challenges of teaching science using a hands-on approach. They referred to the time and effort involved in preparing lessons, and the need to trust students' ability to learn. Listening and facilitation skills also are critical, while increasingly large class sizes and the district's focus on reading and math make it a challenge to find the time to teach the kits. Many teachers complete the three kits that are prescribed by the program, while the fourth strand often goes unattended. One teacher captured the sentiment of many when she said, "teaching reading is 'easy' compared to inquiry science."

Assessment

BSD students in grades K–3 receive grades only on "effort" in science, while students in grades 4–6 receive marks on "performance" and "effort." In addition, teachers use assessments that the GCSP developed specifically to target students' conceptual understanding. These assessments were developed as part of the LSC with accompanying training for teachers in how to use them effectively.

DECISION MAKING AND LEADERSHIP

District-Level Decisions

Decisions about the district's curricula are a core responsibility of the district's curriculum department. The curriculum review process, which is intended to take place on a 7- to 10-year cycle, is quite laborious and inclusive, requiring the involvement of an extensive curriculum review committee. This review committee conducts a detailed assessment of proposed curricula and makes recommendations to the school board for approval or alterations. The school board can accept the recommendations of the committee or act independently, and has done both in the past.

BSD superintendents also have a history of influencing the development, growth, and evolution of new initiatives. For North, their active support paved the way and provided her with the resources she needed to grow the program. Parson was not so fortunate. During her years, the superintendent was not overtly supportive, but neither was he actively resistant. As a result, Parson sought and found her allies in other places and had to make do with meager access to those with ultimate decision-making power. The role the superintendent will have as Harder and Clay continue to lead the program remains to be seen.

School-Level Decisions

BSD principals have long felt limited in their power to make decisions about their school's programming, budget, and resources. They find this quite frustrating, particularly because they are under immense pressure to improve student achievement. While principals have control over professional development programs to improve staff skills, they are hampered by the continual reductions in professional development time. The emphasis on student achievement in reading and mathematics also exerts significant pressure on principals to push teachers in these areas and focus less on science instruction.

Science Program Leadership

Establishing, improving, and providing continuing support for GCSP over the years has required a range of leadership skills each used at the most appropriate time. The first two generations of GCSP leaders had very different styles, but their approaches meshed well with the program's needs and the district context of the time. Looking to the future, Harder and Clay have a strong working relationship and a shared vision of how GCSP should grow. In general, their view of the program's next phase includes deepening teachers' understanding of inquiry, integrating science with the rest of the elementary program, and increasing the likelihood that science will continue to be taught.

RESOURCES AND SUPPORT

FUNDING

A key element of a program's sustainability is the extent to which the district steps in to assume program costs that had previously been supported by outside funds. In 1998–99, GCSP funding included a mix of district and federal Eisenhower funds, as well as remaining LSC funds. Since then, the district has continued to support the science materials center, and has used its Eisenhower funds to support one teacher expert (Harder) and district funds to support the other (Clay). Many administrators expressed their pride in the district's deep level of commitment to the elementary science program. The assistant superintendent for instruction remarked that it was rare to have anything better than "maintenance"-level support, given the BSD budget cuts. "We made a very strong commitment" to the science program, she said.

As the LSC project has shown, outside funding can contribute greatly to program development and ultimate sustainability. However, seeking external grants is not without its costs and challenges. In the BSD, anyone is free to seek external funds. The district's only grantwriter focuses her efforts on large federal grants. There is no formal process for making decisions about which grants to pursue based on alignment with district goals. Rather, the grantwriter explains, "I look for the opportunities within the district and I match them with the external opportunities." In many ways, this approach has served the district well. With help from various program leaders with initiative, drive, and skill, she has raised about $40 million over the past 12 years for much needed support.

Community and Partnerships

In the early years, the local community played a significant role in establishing and developing the elementary science program. Partnerships with local environmental organizations were key assets during North's tenure, offering content expertise as well as moral support. These connections to the community have remained, although they are less intense today. Several local environmental and science organizations have developed program offerings that correspond to the science kits, and some provide space for training sessions and offer a range of experiential programs to the schools in the district. Finally, many of BSD's parents are involved in science or environmental-related work or recreation and, as a result, they seem to appreciate the science curriculum.

ACCOUNTABILITY

Accountability for Student Outcomes

The State Board of Education recently mandated that each local district adopt the state's content and performance standards in reading, writing, and math. It also mandated that all children should be independent readers by the third grade. In response, BSD approved its own, more rigorous standards. Science content standards had also been approved, but as of April 2001, the science performance standards were "caught in a political mess." If tests are developed for science and/or social studies, the director of assessment predicts that they will be implemented in the eighth grade.

BSD's capacity to pursue its own curriculum-driven assessment has been curtailed as a result of the state's assessment program. Since the state has increased its role in testing, BSD's Department of Assessment and Evaluation has reduced its size and scope. Over the course of the 1999–2000 and 2000–2001 school years, its budget was cut by 45 percent with a corresponding cut in staff. There are no district-level tests in place as of 2000–01. Moreover, if curriculum coordinators want to improve their program's assessment tools, they would have to contract with someone outside the district as the department can no longer provide that expertise internally.

Accountability for Teaching the Program

The commitment of teachers and principals to teaching science is extremely variable. Although the extensive training provided via LSC funds went a long way to address teacher reluctance, it still remains a problem. Furthermore, although it is common knowledge that there are resistant teachers and principals across the district, program leaders are unable to discern the magnitude of the problem. This lack of awareness is due to several factors. First, the GCSP does not have the resources to maintain firsthand knowledge of the quantity or quality of science instruction that takes place in schools. The two teacher experts, Harder and Clay, cannot visit enough classrooms in the 60 elementary schools to say with any confidence that they have an accurate account of the status of the program as it is being delivered. And, although the clerks at the science materials center see for themselves how thoroughly a kit has been used when it is returned, this information is not captured and used at this point. The new program leaders are aware of this information gap and are interested in addressing it in the coming years.

Another stumbling block to ensuring science instruction is the voluntary nature of training for new teachers. Central office administrators were pleased that the district chose to fund the teacher expert positions (Harder and Clay) that had previously been supported by LSC funds, and felt that this was a strong step toward ensuring that training for new teachers would continue. However, there still is no way to guarantee that all the teachers who need training on a kit actually attend the training sessions. Many teachers believe that the only guarantee that all students will receive science is the presence of a standardized test in science that is of equal importance to the tests in reading and mathematics.

EQUAL ACCESS TO SCIENCE

Teachers motivated to do so can avoid teaching the kits, and when this happens, the children in those classrooms simply do not receive science instruction. The problem of uneven student engagement in science lessons explains, in large part, the interest that GCSP leaders have in the *Kagan Cooperative Learning Project*. This program has varied learning structures that are designed to ensure that all students in a classroom participate while, at the same time, managing the nature of participation so that it is organized and controlled. In general, teachers involved in the Kagan program report a greater sense of control as well as a greater degree of student engagement that can translate to more widespread, authentic involvement with the science lessons.

SUMMARY

Bolton School District's current program is the natural and obvious descendent of the previous generations of elementary science. The outstanding trait that they all share is perhaps not really a feature of the programs themselves, but of the school district and larger Bolton community in which they are embedded. That trait is an abiding commitment to having children use materials to study science, and it is striking to note how firmly the district identifies its elementary science program with the use of science kits and the science materials center. The long history of the program shows that there have been periods when the program waxed and waned. The district's strong commitment to kits has helped the program take advantage of opportunities to expand, but it has not protected the program from feeling the effects of shocks, be they be related to budget, teacher turnover, or a focus on other subject areas. BSD will never be immune to unpredicted, dramatic, far-reaching events, but its past experience with survival during turbulent times is instructive. Only with hindsight over such a long period of time can one understand the unpredicted and subtle aspects of the program's sustainability.

BOLTON

INTRODUCTION

The Bolton School District's (BSD)[1] hands-on, kit-based elementary science program was a pioneer in the field and has been a key feature of the academic program since the mid-1970's. At that time, Pearl North, a high school science teacher, introduced hands-on science to BSD and, over the course of several years, established a districtwide program. By 1996 the second generation of the program began, led by Dorothy Parson, a former "teacher expert" who reinvigorated it by redesigning the curriculum and expanding the program's depth and breadth. Unlike North, Parson had the assistance of a core team of teachers and a $3.1 million grant from the National Science Foundation (NSF) that targeted districtwide professional development for elementary science. The third and newest generation of the program currently is led by two teacher experts, Sophia Harder and Maria Clay, who took over in 2000. Both Harder and Clay were key players in the NSF grant and bring years of elementary classroom experience and knowledge of science education to the task of moving Bolton's program into the future. Their story and the story of BSD offer a lesson in program evolution and how each stage of historical development contributes to long-term program sustainability.

SUSTAINABILITY: THE ABILITY OF A PROGRAM TO MAINTAIN ITS CORE BELIEFS AND VALUES AND USE THEM TO GUIDE PROGRAM ADAPTATIONS TO CHANGES AND PRESSURES OVER TIME.

CONTEXT

Community Overview

Bolton, with a population of 225,000 is among the largest cities in its largely rural state. It is a center of commerce with finance, real estate, and transportation industries; oil and gas companies; communications companies; and government agencies. While currently in an economic lull, Bolton reaped the benefits of a strong development period during the 1970s. At that time, Bolton underwent a boom with the population undergoing unusual growth, and office space and housing tripling within a 10-year period. Now, economic slowdowns in local industries are having an impact on the community and, in turn, on the schools. With a downturn in the local economy and the job market, the average income per capita is now below the national average, increasing the likelihood that families will leave in search of better wages.

BSD is among the 100 largest districts in the country and serves more than 40 percent of the children in the state. In 2000–01, there were nearly 50,000 students enrolled, an increase of almost five percent since 1993–94.

1 Any individual, organization, or corporation named in this report has been given a pseudonym.

SIZE	
Sq. miles	320
# elem. students	28,000
# elem. schools	60
# elem. classroom teachers	1,144
RESOURCES	
Per pupil expenditure	$6,508
Teacher starting salary	$32,600
NSF funds?	yes
DEMOGRAPHICS	
% students eligible for free/reduced price lunch	30%
% white	62
% African American	9
% Hispanic	6
% Asian/Pacific Islander	9
% Native American	13
% Other	1
YEAR CURRENT PROGRAM BEGAN	**1974**

Figures are for years ranging from 1998–2000. During this time demographics and expenditures shifted and were calculated in a variety of ways.

In 1999, 60 elementary schools in Bolton served over 27,000 students, with 1,300 certified staff and 1,144 classroom teachers. There are 11 middle schools, 6 high schools, and 8 special program schools. Although the district encompasses the municipality of Bolton, which is more than 1,000 square miles, the primary populated area covers about 320 square miles. The remaining area is rural and sparsely populated. The concerns, perspectives, and needs of the populations in the urban and rural areas often are quite different, and this permeates most political debates.

The student population of BSD is moderately diverse. In the elementary grades alone (K–6), as of 1999–2000, white students comprised 62 percent of the population, Native American students 13 percent, African American and Asian Pacific Islander each comprised 9 percent, with Hispanic children accounting for 6 percent. In addition, nearly 11 percent of elementary students are learning English as their second language. Slightly more than 30 percent of BSD elementary students are eligible for free and reduced-price lunch and several thousand students have special needs. Average student mobility over the last several years has remained steady at about 20 percent.

Budget

Most would agree that BSD's budget process and financial status can be quite volatile. Internal and external influences have created enormous instability in the district's budget. The process of setting school budgets in the state is complicated and politicized, involving the competing powers of the school board and the municipal assembly. Although the school board can make line item changes and approves the district's budget, Bolton's municipal assembly has final approval (for more information, see the section on Resources and Support). The groups often differ in approach, as the school board is usually a more liberal, democratic body than the assembly. Further, the president of the Bolton Education Association notes, the funding formula for education has not been adjusted to account for inflation. As a result, the budget is underfunded by 250 percent relative to inflation.

This, exacerbated by economic slowdowns, reductions in the tax base, and the resulting budget cuts over the past 15 years has created a financial crisis. Between 1993 and 1996, the budget was cut by $50 million. Additionally, in the 1997–98 school year, 240 teachers took an early retirement option. As a result, Bolton lost many of its most experienced teachers. Further, Bolton's relatively high teacher salary has been reduced, and for the first time in 15 years, the district has had to recruit new hires. Finally, in an April 2001 municipal election, a $122 million school bond was voted down. The defeat was explained by members of the BSD as the public's reluctance to increase taxes.

Issues of Local Importance

Testing and Standards: Academic testing and standards are lightening rod issues in Bolton as they are across the country. The state has implemented statewide testing in reading, writing, and math, along with exit exams to be given to grade 10 students, which they must pass to graduate. In addition, the state is considering a plan to issue school report cards, which will rate schools as distinguished, proficient, declining, or in crisis. This topic is covered in greater detail in the section on Accountability.

Local Culture: Bolton's population bears a subtle but significant characteristic that has made an impact on the science program. Many are drawn to the outdoors and are predisposed to understanding, protecting, and taking part in the natural world. The importance of the environment is profoundly felt in an immediate, day-to-day manner. The use and protection of natural resources is a compelling public issue. These factors suggest that there is a culture in Bolton already sympathetic to the importance of understanding the environment and teaching science.

PROGRAM HISTORY AND DEVELOPMENT[2]

Program Origins

North understood well the challenge she faced in her new position.

When Pearl North was hired in 1974 to be BSD's second-ever science coordinator, elementary science education was a hodgepodge. A survey administered by Pearl's predecessor demonstrated that there were 21 different science programs in 35 schools. As one teacher recalled, she and her colleagues in the 1970s were "winging it," choosing their own textbooks and methods. North, with only a high school science background and little experience in elementary education, understood this lack of uniformity well. In her doctoral thesis written in 1982, North commented on the educational philosophies of the 1960–70s that endorsed autonomy of the classroom teacher and individual schools. She wrote:

> Freedom of choice of science programs, texts, methods, and even *whether or not to teach science* were all part of the educational choices made by the personnel in individual schools. This allowed some teachers to take the "easy way out" by excluding science from their classrooms, while others used a "read-about" approach without becoming involved in science activities.

Having studied teachers' decisions about their classroom practice, North understood well the challenge she faced in her new position. She had a

2 For a timeline of this site's history, see Appendix C.

mandate from the former director of elementary education to create "one science program," and from the principals to "do something with all the science junk in the back closets!"

North educated herself by attending many NSF-funded institutes to look at different approaches. Eventually, she learned about a program in a nearby state, and in 1974, she went there to talk to its director to learn more. "That was the turning point for Bolton," she recalls. The leader of that program, Carlton Monahan, inspired North's fledgling work in Bolton and, along with other science leaders in the nation at that time, guided her in shaping Bolton's hands-on kit-based program.

North cultivated district support as she simultaneously developed her own vision for elementary science.

Over the next several years, North cultivated district support as she simultaneously developed her own vision for elementary science. She brought Monahan to Bolton in 1975 to teach workshops and introduce the teaching community to hands-on science, and followed up by establishing a committee of principals whom she felt would be most interested in hands-on science. This group met monthly and endorsed the development of a program that would supply materials to teachers. They also found centralized coordination of such a program appealing. Monahan returned to advise North and her committee further, this time focusing on issues related to implementing the science kits. Finally, North brought the Bolton director of curriculum to visit Monahan's district, and he was drawn to the hands-on approach. He would remember his experience in the years to come and offer North support as she worked to establish a similar program in Bolton.

In 1975–76, using commercial kits as a model and the expertise of local teachers and environmentalists, North set out to develop kits tailored specifically to the BSD schools. She went to the elementary buildings and emptied their closets of old science resources, salvaging useful ones for the kits. As she proceeded with her fledgling program, North engaged BSD teachers and the environmental organizations of the community in the process of designing and creating the kits. She also secured financial support for kits, field trips, and other science-related activities from local business foundations and professional associations.

Her activities at the time all focused on getting kids' hands on the "stuff of science."

North recalls her activities at the time as a whirlwind of activity all focused on getting kids' hands on the "stuff of science." Teams of volunteers worked late into the night assembling kit materials—from plucking feathers from birds donated by the Department of Fish and Wildlife to counting rubber bands. It was, North recalls, "hard, exhausting, and tremendously fun work."

North continued to receive support within the district, and in 1977, the audio-visual coordinator, later to become an assistant superintendent, offered North $19,000 from the AV budget as a contribution to the science program. Evidently, he wanted to see Monahan's model enacted in Bolton, and, North recalls, could afford to be generous in those "boom" years. North used the money for materials purchases and cost-sharing contributions toward storing and transporting the first kits.

North also cultivated the early and strong support of two superintendents who provided the program with valuable assistance during this time of establishment. One even accompanied her to a science institute and later remarked that he felt it was his job to "direct resources toward people like Pearl." He spoke of "creating an environment where Pearl can do her work, and maintaining an awareness of her activities so that I could work with principals and help them support her program." North was establishing a strong foundation on which her program would build.

North was establishing a strong foundation on which her program would build.

North delivered the first batch of kits to seven volunteer schools in December 1977. Each of the school principals had committed to providing financial support for a shared "resource teacher" and an aide. North introduced the program in each school by bringing a kit, doing a lesson for teachers to observe, and then leaving the kit for others to try on a voluntary basis. North returned to the schools to give workshops, and by the end of that academic year, many teachers in the seven schools were ready to teach a whole kit to their students.

Over the next two years, the program began to solidify. Kit use expanded to 38 schools by the end of 1979, and when the program outgrew its storage space, North accepted an offer from the AV Department for new kit storage space. North formalized the original committee of principals as the Elementary Science Curriculum Committee. They supported and advised North, advocated for the program, and helped expand it. By the very early 1980s, all elementary schools were using the kits on a voluntary basis, while other materials (e.g., film loops, live animals, potting soil, magnets) were also available to teachers. North managed the program along with a staff that had now expanded to three clerks managing the materials center and four resource teachers.

In 1981, the program passed a key landmark. The Elementary Science Curriculum Committee recommended to the school board that they eliminate the use of elementary science textbooks for the science materials adoption, and use kits exclusively. The school board agreed, and with that decision, the science kits became the official elementary science program for the BSD.

North had established a good relationship with the board, and demonstrated for them how kits were used in classrooms.

According to North, several factors contributed to the board's positive vote. First, the kits were helping the district achieve its scope and sequence goals. Second, relations between the program and the school board were strong. The director of elementary education, North's supervisor, had done a good job laying the groundwork with the board, introducing them to the program early on. The director of curriculum at the time also mentioned that North had established a good relationship with the board, and demonstrated for them how kits were used in classrooms. Third, North's visibility at NSTA conferences, which helped her own professional development, also helped to legitimize the value of hands-on science. Fourth, North's dissertation data demonstrated that students using kits had significantly better attitudes toward science than students who used textbooks. And finally, North did a cost analysis of kit programs versus textbook programs and made a convincing argument that cost was not greater for hands-on science.

Administrators' support was grounded in the fact that they had many opportunities to view the program in operation and liked what they saw.

As the program grew and eventually peaked in the early 1980s, central office administrators and the board continued their support. In its heyday, the program had eight resource teachers, who took the kits into classrooms and demonstrated their use. North speculates that the administrators' support was grounded in the fact that they had many opportunities to view the program in operation and liked what they saw. According to North, they could see "a districtwide program in which teachers were teaching science, increased interest in elementary science fairs, interest in science on the part of children entering middle school, and teachers participating in in-service training."

Early Program Content

The content of the program generally consisted of lesson plans for each grade level that were assembled into notebooks and given to each classroom teacher by the science materials center. Accounts of the pedagogical approaches conveyed in those lesson plans vary somewhat, from those who describe a more prescriptive approach to those who recall more flexibility. Teachers ordered kits from the AV Department, and they would be delivered some time later. Teachers used the kits for three to five weeks before returning them to the materials center for refurbishment.

Some recalled that teachers reluctant to teach science used the resource teachers' kit demonstrations as the students' science lesson.

Recollections of the strengths and weaknesses of the program vary. Some recalled that teachers reluctant to teach science used the resource teachers' kit demonstrations as the students' science lesson rather than as an opportunity to learn how to use the kits themselves. For those students, the demonstrations were the only science instruction they received. Others recalled that teachers felt the kits were too open-ended and didn't come with enough guidance. Still others noted the limitations of the organizational system and how they didn't know if they were going to get the kit they ordered until just before it arrived.

The former director of the AV Department remembered that a system was used to track teacher's kit usage. This system was designed to help principals ensure that science was being taught in their buildings. Although it is unclear whether the system was actually used, it is very clear that, even at its high point, the ongoing challenge was to encourage all elementary teachers to teach science.

The Decline of the First Generation Program

Beginning in the early 1970s, local industry brought a lot of money to the district, and resources for education were abundant. One former teacher recalled, for example, that in her first year of teaching, she started at a salary of $9,000, and by the end of the year it had been increased to $15,000. This abundance gave North the resources she needed to establish and grow her program. By the mid-1980s, however, the district felt considerable stress as local industry slowed, resulting in loss of revenue and cuts in the district's budget.

Between 1986 and 1988, the superintendent who was new to the district, cut $12 million, $13 million, and $16.9 million from the budget each successive year, including a five percent cut in his own salary. The impact of these cuts on the elementary science program was profound. Staff and refurbishment supplies were cut, and by 1985 the eight resource teachers were reduced to four. In 1985–86 there were three; in 1987–88 there were two; and then in 1988–89, the resource teachers were eliminated altogether. North and the materials center staff were left to manage the program on their own.

Another factor contributing to the decline of the program was the emphasis on reading and mathematics standardized tests. The director of curriculum and evaluation explained that because these tests did not include science, they diverted attention away from the program and led many teachers to lose their commitment to science teaching. By the end of the 1980s, kit use was estimated to cover only two-thirds of BSD classrooms. Several principals commented that the science program's lack of structure and training also left it vulnerable to cutbacks.

The science program's lack of structure and training also left it vulnerable to cutbacks.

In 1987, even as the budget cuts were being made, the science program went through a revision. As part of the district's regular cycle of curriculum review, the resource teachers initiated what was to be a two-year process to improve the quality of the kits. Using kit evaluations from teachers and their own review of the materials, they identified areas for improvement. The Elementary Science Curriculum Committee of principals worked on designing part of the curriculum framework, while the resource teachers, with help from a team of classroom teachers, expanded some of the kits and developed more of the curriculum over a summer. They established a template for each lesson, "tweaking" some and substantially expanding others. Unfortunately, the system for refurbishment and delivery was not changed, and it continued to be unpredictable and problematic.

The revised kits were "very cookbook," recalled a resource teacher, presumably in response to earlier complaints about "too little structure." A typical kit contained lists of materials, process skills, and terminology; unit objectives; vocabulary; background information for the teacher; and specific lessons, some with assessments. And yet, even with the improvement efforts, in the face of reduced financial and administrative support, the program continued to weaken.

Even with improvement efforts, in the face of reduced financial and administrative support, the program continued to weaken.

Then, in the fall of 1989, after a year had passed without any support in science for elementary classroom teachers, central office administrators recognized that it was time to attend to the diminished science program. Dorothy Parson, the program's future leader, was hired as a teacher expert. Originally a reading teacher, she had been working on her doctorate at Bolton University when she became interested in the inquiry approach to learning and science. Different from earlier resource teachers, who focused on school site support, as "teacher expert," should would take on the leadership of the rejuvenation of the science program districtwide. Also at that time, recognizing that it was due for an adoption of elementary science materials, the district allocated the $750,000 in elementary science adoption money to refurbish the newly revised kits and increase their number. With these new resources, the director of curriculum and evaluation called for a closer look at the coordination of the science program across and within grades and at the extent to which it reflected current pedagogy. A program revival had begun.

A program revival had begun.

Second Generation

The first generation of the program focused on establishing the use of kits across the district. The second generation built on this foundation and brought it further by focusing on strengthening the quality of the curriculum and instruction. Just as the curriculum revision process had started years before, Parson began with a survey that targeted gathering information about the details of the current program. She asked teachers how they felt about the kits, what they thought needed improvement, and what they felt were important issues to consider regarding elementary science. Armed with this data, Parson went on to consider how the curriculum was organized within each grade and from one grade to the next.

Parson asked teachers how they felt about the kits, what they thought needed improvement, and what they felt were important issues to consider regarding elementary science.

Then in 1991, she took a team comprising a teacher, a principal, herself, and the director of elementary education to the Next Steps Conference in Washington, D.C[3] Based on their work at this meeting, Parson formed a core team of 24 teachers from across all grades, and they began planning the curriculum by asking the question, "What do we want kids to know by the time they finish the sixth grade?" Their goal was to create a more structured scope and sequence for the curriculum so that instruction reflected a larger educational plan rather than individual teachers' interests in teaching particular kits. Their thinking was guided by a national discussion that was taking shape following the publication of *Science for all Americans*[4] and Project 2061's *Benchmarks for Science Literacy*[5]. This planning took about two years to complete.

As the work progressed, Parson and her team revisited the kits they had in place. Based on the developing new framework, they revised existing kits and added new ones, including some that were now commercially available. Then in 1992, a grant from the U.S. Department of Education enabled the core team to complete the grade-level framework and thoroughly field-test the new kits. This process took approximately 18 months, and according to

3 NEXT STEPS was originally sponsored by the Association of Science Materials Centers and now is jointly run by ASMC and the National Science Resources Center (NSRC).
4 Rutherford, F.J. and Ahlgren, A. (1991). New York: Oxford University Press.
5 Project 2061. (1993). New York: Oxford University Press.

the district's science coordinator, it was a crucial period for the program. This grant afforded the team an opportunity to ensure that the final products would be well-grounded and proven in the field.

> Even with the participatory process of testing kits and organizing a coherent curriculum, teachers still would not easily give up their freedom to select the kits they would teach.

The Arrival of LSC funds

Parson recognized that even with the participatory process of testing kits and organizing a coherent curriculum, teachers still would not easily give up their freedom to select the kits they would teach. And even those who were willing would need training on the new curriculum. So, in an attempt to obtain the funds necessary to fully implement the new curriculum as planned, Parson applied to NSF for a Local Systemic Change (LSC) grant. This funding would support large-scale professional development as well as other needs associated with a districtwide overhaul of curriculum. The BSD was successful, and when field-testing was completed in 1995, $3.1 million in LSC funds enabled a massive, four-year training effort that would involve every elementary teacher each year. Parson became the director of the LSC grant and hired two new teacher experts, Sophia Harder and Maria Clay, to help support the work of the grant. The training was largely mandatory and took place during the school day, enabling the implementation of the new curriculum in the first full year of the grant.

School Science Consultants: The training and leadership strategy for the LSC project focused on the development of a group of teacher leaders. Called "school science consultants (SSCs)," they were intended to help sustain the program by forming primary (K–3) and intermediate (4–6) teacher teams at their schools, and then supporting these teams by answering questions and assisting with kit management. The LSC-funded training for SSCs began in 1995 and focused on both content and leadership skills. A total of 122 volunteers from across all of the elementary schools attended. In total, about 325 teachers received this training over the years. Participants found it extremely valuable, resulting in improvements in their content knowledge, pedagogical strategies, and in leadership skills for advocating for science in their schools. Some SSCs were careful to say, however, that regardless of the high standards set by their training, when interacting with teachers in the schools, they had to be very careful to present a "helping" hand rather than a judgmental one. In fact, the union took action against one trainer who was perceived to be evaluating teachers' performance.

> Participants found the training extremely valuable, resulting in improvements in their content knowledge, pedagogical strategies, and in leadership skills.

Despite the resources directed toward their training, the general consensus among Parson, the teacher experts, teachers, and principals, was that the promise of the SSCs was not fully realized. When the LSC project was complete, SSCs were primarily assisting with kit orders, a minimal function compared with the broader, original goals. As of March 2001, some schools no longer even had any SSCs. The small numbers of active SSCs made it difficult for them to sustain each other or make a significant impact on the

> The general consensus was that the promise of the SSCs was not fully realized.

sustainability of the program. The interest in future years in establishing the Science Leadership Cadre (discussed in an upcoming section) was in part a response to the dwindling role of the SSCs.

Program participants offered several possible reasons for the SSC's lack of impact. First, some SSCs had little lasting interest in science. Many were unwilling to continue to make such a high investment in supporting science when the LSC no longer compensated them for their time. Second, their building colleagues were not always aware of how to use their services. Third, after the initial focus on SSCs waned, their presence became even less obvious.

LSC Professional Development: Full scale, mandatory training on the kits began in 1995–1996. Each of the 1,080 elementary teachers was released for a total of three days for grade-level training over the year. The training focused on a general introduction to the curriculum at that grade, with specific training targeting the three kits they would be teaching in that year. Teachers also got support for the monthly grade-level meetings facilitated by SSCs. Principals were updated about the project during their regularly scheduled meetings.

An increase in teacher turnover posed a challenge to the project.

In the second year, 1996–1997, an increase in teacher turnover posed a challenge to the project. The teacher turnover was the result of an early retirement package that the district offered in response to a budget crisis. One-tenth of BSD's teachers accepted. As a result, 450 teachers moved to new grades. The training that originally was conceived to focus on integration of science with social studies, language arts, and mathematics had to be significantly altered to accommodate the needs of these new-to-grade teachers.

Although the value of the rigorous training schedule was clear, the cost in the upheaval it caused was high.

The rigorous LSC training schedule also raised new concerns. The schedule required that in each school building, each grade level of teachers would be out of the classroom for each of the three training days, making a total of 21 days that the school would not have its complete staff on site. Teachers, principals, and board members worried about the impact that these extensive absences would have on instruction. Although the value to project implementation was clear, the cost in the upheaval it caused was high.

In the final year of the LSC project, 1999–2000, teachers could attend a variety of training opportunities that were financed with a mix of LSC, district, and Eisenhower funds. A one-day session prior to the start of the school year for new-to-district teachers (for which they received a $100 stipend) introduced the scope and sequence of the science program and provided a national perspective on science education with an emphasis on inquiry. Teachers also could attend (for a $50 stipend) an optional Saturday half-day kit training workshop that was intended to coincide with kit rotation. Also offered was a one-day mandatory session—a "big idea" workshop—for teachers who had been in the district three years or less. The workshop tried to replicate, more succinctly, the first stage of LSC training. These sessions used scientists to present science concepts and "big ideas" for the different grade levels and also emphasized kit assessment.

Throughout the project, teacher training was very well received. As a result of building teacher's content knowledge, teaching skills, and confidence, "Better teachers are teaching better science," the district's science coordinator observed.

> ***Professional Development—Spreading Philosophy***
>
> "Big Idea" workshops, required for all teachers new to the district, served to convey the philosophy of the program in concrete but subtle ways. In a sixth grade workshop on Scale and Structure, for example, teachers first experienced an open-ended inquiry lesson that focused on the spatial relationships of the planets. Then, an astronomer illustrated how the big ideas of scale and structure could be explored through such a lesson. Although there was little explicitly communicated to teachers about inquiry, all of the workshop leaders demonstrated these concepts and practices masterfully.

Improving Kit Management: In 1995, Parson improved and upgraded the previously problematic kit management process. A new procedure for ordering had several positive effects. First, it improved the efficiency and reliability of the science materials center's kit delivery and refurbishment process. Second, it enabled teachers to request the next year's kits in the spring so they knew far in advance when each kit would arrive and could plan accordingly. And third, supported by the newly created scope and sequence, each classroom in a grade level in a building would teach the same kit at the same time, allowing for more shared discussion and support among teachers.

> ***Professional Development—Demonstrating the Need for Accountability***
>
> New-to-district and new-to-grade-level teachers were offered the opportunity to participate in a first-use kit training, but only about 13 percent did so. Although the session was broadly publicized, there was no mechanism for leaders to know how many teachers were new to their grades and in which schools they were teaching. As a result, it was difficult to alert them specifically to professional development opportunities. The implication for sustainability is obvious. Without the ability to introduce new teachers to the curriculum, the likelihood that they will teach it, much less teach it as intended, is jeopardized.

Involvement of Principals: The involvement of principals in the LSC years was considered critical for sustainability by program leaders and others. In retrospect, many believe it was not as effective as they had hoped. With North's principals' committee no longer playing a role, the LSC project called for principals to participate in two training sessions. The first was mandatory and introduced principals to inquiry science and the elementary science curriculum in Bolton, and also gave them an opportunity to experience a science kit as students would. Both the assistant superintendent of instruction and the director of elementary education sent a strong message to the principals that they supported this training and, indeed, it received positive reviews. The second training session was not mandatory, stressed different points, and was not considered to be very useful by those who attended.

Overall, principals' responses to the LSC project were mixed, and it was generally acknowledged that the weakest link in the project was the failure to engage them. Leaders had hoped principals would take on the responsibility of ensuring that science was always taught, but this generally was not the case. Evidently, the principals' general training was not sufficient to build a strong base of support for science instruction.

The Third Generation

Their principal concern rested in making the transition from a large, time-limited, externally-funded project to an internally supported, institutionalized district science program.

In 2000, as LSC funds wound down, Parson prepared to leave her position. The two strong teacher experts, Sophia Harder and Maria Clay, now stepped forward to take the reins. Their principal concern rested in making the transition from a large, time-limited, externally-funded project to an internally supported, institutionalized district science program. They, as well as teachers, principals, and administrators, were anxious about the void that would be left by the end of the LSC funding, and no one was sure how to fill it. As a first step, they knew they needed to assess the degree of professional development necessary to maintain the integrity of classroom instruction and sustain those with leadership responsibilities.

Their intention was to develop a group that would have a deep understanding of science and science teaching, and then would apply that knowledge to their roles as district leaders.

Harder and Clay returned to the idea of developing a core team of teacher leaders, much like Parson had done with her team of 24 before the arrival of the LSC. Their intention was to develop a group that would have a deep understanding of science and science teaching, and then would apply that knowledge to their roles as district leaders. They applied for and received a $10,000 grant from a local science and mathematics consortium of schools and used those funds to develop the Core of Science Leaders (CSL). Twenty-two teachers representing a range of grades and experience in the district participated. They held a retreat, formed study groups to strengthen their understanding of the unifying concepts of the science program, and assisted with the first-use kit trainings. Of the 21 first-use sessions presented in April 2001, six were presented by CSL members.

In May 2000, before Parson's departure, she reflected on sustainability, the LSC, and what she might have done differently. She questioned the "bulldozer" training strategy and wondered if it would have been better to focus on quality rather than quantity, and on keeping the message clear, consistent, and true to inquiry's purpose. Specifically, she wondered if her general acceptance of classroom teachers as kit trainers had resulted in a "watered down and changed" message. She also realized that she could have been more strategic about building program support by hiring a full-time community liaison, adding better-positioned individuals to her LSC advisory board, and keeping closer ties to the directors of elementary education. Finally, she observed that although she might handle the next phase of the program differently than Clay and Harder, the program was in good hands and it would (and should) develop in a way that reflects their unique styles and interests rather than her own.

THE CURRENT PROGRAM

CURRICULUM[6]

With the conclusion of the LSC project, the Global Community Science Program (GCSP), as it has become known, continues as the district's kit-based, elementary science program. Each classroom teacher is expected to use three kits per year with each kit covering a seven- to eight-week period. The kits are prescribed by the program and cover three strands: life science, physical science, and earth science. A fourth strand, known as "Explorations in Science," is an opportunity for teachers to explore topics that respond to the particular interests of their classes and/or to a community issue.

Science Materials Center

The science materials center, currently run by an administrative assistant and three clerks, continues to enjoy strong support from the district. Originally housed in the AV Department, it has been moved to the district's warehouse and now is quickly outgrowing the space. Management of the materials center is an ongoing concern that was particularly prominent during the transition from LSC funds. Parson wanted to reduce the time science program leaders spent on materials management and worked to ensure systems were put in place to guarantee kits' timely pick up, refurbishment, and delivery. The BSD adopted a new computer-based inventory system, revamped the way vendor information and ordering procedures were managed, and developing a sophisticated ordering and distribution system to process teachers' spring kit rotation requests.

Curriculum Approval and Oversight

The director of elementary education, a position that has seen turnover for each year from 1998–2000, oversees the elementary science program. This upheaval has made planning and following through on initiatives very diffi-

6 For an overview of the curriculum units used at this site, see Appendix D.

cult. In 1999–2000, a well-respected, former BSD principal took over the position, bringing much needed stability and consistency to the elementary program.

The board was scheduled to review the elementary science curriculum in 1999–2000, but this did not occur. Recognizing that the school board and curriculum committee approval of North's proposed kit program in the early years was an important boost and milestone for the program, GCSP leaders were disappointed in the delay. It would have given them the opportunity to raise awareness of the program and improve the chances for revitalizing support.

Enthusiasm for and use of the science materials suffer from a nearly universal complaint that the schools simply have too much curricula.

Enthusiasm for and use of the science materials suffer from a nearly universal complaint from teachers, principals, and central administrators that the schools simply have too much curricula. Teachers spoke of the critical need to integrate curricula and of the lack of support to do so. Elementary teachers noted that all of the curriculum coordinators are former high school teachers whose tendency, they believe, is to focus more on their own disciplines and less on how subjects can relate to each other in elementary classrooms. Teachers are frustrated and anxious about the need to cover so much material and feel they need guidance to help them do so effectively.

Kagan Cooperative Learning Project

The BSD has pursued four initiatives over the past few years that may influence sustainability of the science program, either by enhancing it or detracting from it. Although they have different objectives, the initiatives share a common focus on the integration of science with reading, math, and other subject areas. Each has captured the imagination of one or more central office administrators who has taken it on as his or her special interest. One of these initiatives, the *Kagan Cooperative Learning Project*, deserves special attention in that it has had a districtwide impact on elementary instruction—including science. The program helps teachers structure and manage children's group work so that it enriches learning opportunities for all members of a class. With such classroom management skills, teachers are more willing to teach hands-on science. In recognition of Kagan's importance to the science program, Parson gave $50,000 of LSC funds to this initiative.

Over the next three years, teachers and principals were introduced to the approach. Becoming a "Kagan school" requires considerable training for both the principal and at least 80 percent of a school's teachers (30 hours for each teacher alone). Even so, 20 schools adopted it, and Kagan's teaching methods have spread throughout the elementary program. Each science kit now includes suggestions for appropriate Kagan techniques that teachers can use throughout each unit. The mathematics and bilingual departments also emphasize Kagan techniques and principles. While it is too soon to predict whether the *Kagan Cooperative Learning Project* will have a long-term impact on the sustainability of the science program, it has significant potential.

Instruction

The research team observed 20 science classes across grades K–6 at 10 (17 percent) Bolton elementary schools. Classrooms and schools varied dramatically. The student population of a classroom ranged from having one or two students of color to being two-thirds of color. Several had many students with special needs, including children with poor reading skills and some with behavioral problems. The schools represented a wide range of socio-economic levels (from poverty level to upper middle income) and varied in their geographic location. Kagan's cooperative learning methods were evident in 4 of the 10 classrooms. These teachers tended to use a greater repertoire of methods for organizing students' reflection, action, and sharing in the classroom. Most teachers demonstrated strong skills as coaches and facilitators. The majority had been SSCs with their experience ranging from 4–24 years.

Teachers hold a wide range of opinions of the kits.

Kit Use: The extent to which kits are actually used by teachers is unknown, but it is clear that it varies from teacher to teacher and school to school with those teachers who use none of the kits in the extreme minority. Teachers hold a wide range of opinions of the kits. Some feel they are too prescriptive. One second grade teacher, for example, said the kits were "too lock-step," and she wanted more freedom to experiment and expand. Others felt that the kits need to be more "user-friendly" and that more instruction and guidance included in a kit would increase its use. Still other teachers felt completely at home with the kits and are comfortable expanding or contracting them according to the needs and interests of their students. Most agree that the improved kit assessments (see description in section on Assessment below) help teachers a great deal because they make the learning goals for each kit very clear. Also, many teachers add their own materials to those in the kits, and some schools provide teachers with additional funds for this purpose.

Most agree that the improved kit assessments help teachers a great deal.

In the survey administered by this research project, teachers indicated that they clearly heard the message that they are expected to teach three kits per year. Of those responding, 9 out of 10 indicated that they used three kits. Similarly, nearly all of the principals reported that they viewed the kits as "very important"—the highest possible rating. Additionally, over half of the responding teachers indicated that they "very rarely" use textbooks with nearly all of the remaining half reporting that they use them only "sometimes" or indicating that the question was not applicable to them (one could infer that they don't use texts at all). While this suggests that nearly all teachers are teaching the core, it simultaneously indicates that few teachers are teaching a kit in the fourth strand, "Explorations in Science." Further, in 2000, only one and one half years after the end of the LSC, the number of teachers who reported having been trained to use their grade's kits has dropped to less than half.

Over the evolution of the program the program leaders' definitions of inquiry instruction in science were not static.

Goals for the Science Program

Parson informally defined good science instruction as that which uses the curriculum but modifies it to meet student needs, encourages questioning and self-directed investigation by students, integrates science with other subjects, and creates a positive environment in which all kids participate. However, there was no evidence that she specifically articulated this definition to the teachers. Presumably, it describes the kind of instruction that the LSC training tried to foster and, thus, is a useful lens for interpreting the instruction observed. Few classrooms demonstrated student-directed investigations, but in many, regardless of grade level, there was evidence of the use of literature and thematic integration. It was common to see guided investigations and teachers encouraging lively student questioning. On the whole, teachers exhibited a high level of comfort with the use of materials as well as with their students' active engagement with them.

Over the evolution of the program the program leaders' definitions of inquiry instruction in science were not static. Their individual views evolved over time and they had differing perspectives. They pointed out that their understanding of inquiry was continually evolving and influenced by their attendance at various institutes and conferences. The effect of this evolution of thinking on the program can be seen in their changing attitudes about the degree to which use of the kits should be prescribed versus allowing teachers more creativity and choice.

In general, teachers expressed a desire for students to develop their natural curiosity and enthusiasm for doing science. One teacher commented, "I want them to experience science, and these kits allow them to do that," while another said she wanted "to encourage each child to participate and get their hands in it at this age." Another typical comment—"I want the kids to pose their own questions for their own experiments and give them the opportunity to test some things"—reflected a general interest in having their students understand the scientific process as well as particular science concepts. Finally, many teachers mentioned that they wanted to foster the joy of learning and exploration. As one succinctly stated, "I think these kits allow them to be 'Curious Georges' and really see that science can be fun."

Teachers also discussed the challenges of teaching science using a hands-on approach. They referred to the time and effort involved in preparing lessons, and the need to trust students' ability to learn. Listening and facilitation skills also were critical, while increasingly large class sizes and the district's focus on reading and math made it a challenge to find the time to teach the kits. Many teachers managed to get through the three kits that were prescribed by the program, while the fourth strand, *Investigations and Applications*, often went unattended. Teachers mentioned how important classroom management skills were, particularly for ensuring that all students in the class had an opportunity to participate, contribute, and learn from the experiences. One teacher captured the sentiment of many when she said, "teaching reading is "easy" compared to inquiry science."

Erosion

A group of five grade 4 students crowd around a table, while one student, holding a paper cup full of water above a large tray half full of sand, begins to pour. Students are learning about erosion and sedimentation by observing the effects of water on sand. "How could you change the velocity of the water?" asked the teacher, Ms. Cross. Students offered several ideas. Minutes later some students had prepared paper cups with different sized holes, others had recorded several predictions, while all had their science journals and pencils at the ready. The group's investigation of erosion had begun.

Assessment

BSD students in grades K–3 receive grades only on "effort" in science, while students in grades 4–6 receive marks on "performance" and "effort." In addition, teachers use assessments that the GCSP developed specifically to target students' conceptual understanding. These assessments were developed as part of the LSC with accompanying training for teachers in how to use them effectively. Clay believed that only about five percent used them as intended—to assess conceptual understanding. She estimated that perhaps 75 percent of the teachers didn't actually administer and interpret the results of the assessments, but rather looked at them to help determine what they would and would not teach. The remaining 20 percent, Clay felt, didn't use the kit assessments at all.

Due to the varied and largely untracked use of assessments, a determination of student learning in science remains unclear. It is likely that student learning is somewhat idiosyncratic, varying widely across the district. With the emphasis on effort in the lower grades, most teachers of younger students likely pay less attention to mastery of the curriculum. The limited use of the kit assessments notwithstanding, GCSP made an impact on the district through its development of assessment tools and its approach to training teachers to use them. In fact, GCSP was regarded as a model and even was adopted by the director of evaluation and assessment for the development of an electronic reading assessment.

Professional Development

Shifts in the district's professional development practices have a potential effect on the program's sustainability. Most striking is the decline in the amount of professional development available to teachers. During the "big money" days of economic growth, the district paid for as many as 200 release days for professional development in each curricular area, kindergarten through grade 12 (distinct from externally-funded training, such as the LSC). Now only 50 days of professional development are available to be shared across the grades and across curricula. Moreover, the union's contract requires that several of those days are spent on completing students' report cards and so are unavailable for curricular-focused activities.

Another important emerging issue is teachers' reluctance to attend professional development activities on their own time. Many are adamant that they should be adequately paid for the time they spend in training. This is particularly noteworthy because while the district provided training specifically for new-to-grade and new-to-district teachers, these sessions are voluntary and lightly attended in part because many teachers consider the small stipend insufficient compensation.

Another factor is principals' new interest in their own professional development. The BSD requires that principals attend two full in-service days of

Exploring Circuits

Groups of grade 6 students are faced with the challenge of constructing circuits. They look at the batteries, bulb holders, bulbs, motors, and copper wire spread out before them and start "messing about." They make a series circuit, record their group work, and write in their own science notebooks. The teacher, Mrs. Veneble, interacts constantly with them, asking questions and provoking deeper science thinking. As she introduces new challenges, such as adding bulbs or adding parallel circuits, she probes, "What happens to the brightness of this light? Have you measured it?" They close the lesson by writing questions they will investigate when they return to the unit the next day and Mrs. Veneble reminds them, "Remember- we can learn just as much from the ones that that do not work as the ones that do."

training during the school year and three days of training in August. The director of instructional support oversees principal training and sets the agenda based on feedback gathered through surveys as well as directives from the school board and superintendent. For the first time in years, in response to the district's focus on performance standards, principals recently requested that their professional development emphasize curriculum. There is an opportunity here for coordination between science and other subjects, but there is little evidence that this has taken place in the past, or that it is on the agenda for the near term.

It is likely that student learning is somewhat idiosyncratic, varying widely across the district.

There is an opportunity for coordination between science and other subjects, but there is little evidence that this has taken place.

A final aspect of professional development linked to the sustainability of the program is the value that science program leaders, current and past, place on their own ongoing professional development. They explain that experiences, such as National Science Resources Center (NSRC) workshops, keep them informed, connected to other experts in their field, and inspired to continue to develop their programs. These experiences have not only benefited them, but have contributed to a larger support network of science educators across the country.

DECISION MAKING AND LEADERSHIP

The BSD's decision-making process—at the school level, the district level, and within the program itself—has had a profound effect on the growth and evolution of the science program. In general, communication in the BSD seems to be driven by its departmental structure, so that within departments communication is frequent, but communication between departments is much more limited. It seems that decision-making procedures are shaped less by an organizational framework and more by personal relationships within departments.

Decision-making procedures are shaped less by an organizational framework and more by personal relationships within departments.

Several administrators suggested that the district has a competitive nature, but were optimistic that this has improved somewhat in recent years and would continue to do so. In 1999–2000, the administrative offices were relocated to a building shared with all of the curriculum departments, technology, and a new training facility. The move was frequently cited as a key development with the potential to vastly improve communication within the BSD.

District-Level Decisions

Decisions about the district's curricula are a core responsibility of the district's curriculum department. The curriculum review process, which is intended to take place on a 7- to 10-year cycle, is quite laborious and inclusive, requiring the involvement of a curriculum review committee composed of teachers, parents, and principals from elementary, middle, and high schools; community members; administrators; school board members; business representatives; and representatives from the bilingual, multi-cultural, Indian education, and special education groups. This review committee conducts a detailed assessment of proposed curricula and makes recommendations to the school board for approval or alterations. The school board can accept the recommendations of the committee or act independently, and has done both in the past.

The board's willingness to exercise its power in this way suggests the importance of establishing sound and reliable communication mechanisms between the curriculum department and the school board. The current informal manner in which information about curricula and school-level practice flows between them is unreliable. Although North had relatively easy access to the board in the early days (assisted by the support of her first two superintendents) and provided them with information about the science program, that has not been the case for science program leaders over the past 10 years. In fact, leaders from many departments have expressed frustration with their unsuccessful efforts to get on the board's agenda.

The power of the superintendent to influence the development, growth, and evolution of new initiatives is evident from as far back as North's early years.

The power of the superintendent to influence the development, growth, and evolution of new initiatives also is evident from as far back as North's early years. For her, their active support paved the way and provided her with the resources she needed to grow the program. Parson was not so fortunate. During her years, the superintendent was not overtly supportive, but neither was he actively resistant. As a result, Parson sought and found her allies in other places and had to make do with meager access to those with ultimate decision-making power. The role the superintendent will have as Harder and Clay continue to lead the program remains to be seen.

School-Level Decisions

The BSD principals have long felt limited in their power to make decisions about their school's programming, budget, and resources. They find this quite frustrating, particularly because they are under immense pressure to improve student achievement. While principals have control over professional development programs to improve staff skills, they are hampered by the continual reductions in professional development time. The emphasis on student achievement in reading and mathematics also exerts significant pressure on principals to push teachers in these areas and focus less on science instruction. As one principal remarked, "A principal has to be interested in science in the first place if they are going to go to the trouble of emphasizing it with their staff." In the absence of a principal's personal interest in science, science instruction may simply fall by the wayside, particularly when a teacher is also reluctant.

Elementary Science Program Leadership

Establishing, improving, and providing continuing support for GCSP over the years has required a range of leadership skills each used at the most appropriate time. The first two generations of GCSP leaders had very dif-

> Establishing, improving, and providing continuing support for GCSP has required a range of leadership skills each used at the most appropriate time.

ferent styles, but their approaches meshed well with the program's needs and the district context of the time. For example, North's vision and persuasive style enabled her to attract teachers and principals to using the kits. Moreover, she garnered the much-needed support of educational and political leaders that the establishment of a groundbreaking science program required. In contrast, Parson's vision and deep understanding of classroom instruction and professional development enabled her to reinvent the science curriculum. Further, by establishing a period of well-orchestrated professional development, she was able to reestablish the science program's importance in the district.

Looking to the future, Harder and Clay have a strong working relationship and a shared vision of how GCSP should grow. In general, their view of the program's next phase includes deepening teachers' understanding of inquiry, integrating science with the rest of the elementary program, and increasing the likelihood that science will continue to be taught. Clay is particularly interested in the integration of science with other curricula, and Harder wants to push teachers' understanding and use of inquiry in the classroom. They both have ideas about improving communication between teachers and the program leaders, increasing the practical use of the kit-usage data that the materials center gathers, and providing coaching for teachers.

District Science Leadership

Another important leadership role with regard to the elementary science program is the science coordinator for the district. North left the position in 1993, and her successor has been a sympathetic supporter of GCSP, relying on Parson to promote the program. In September of 2000, a new district science coordinator took on the job following the previous coordinator's retirement. The current coordinator has been involved in a program supporting innovative practice for a select group of middle and high school teachers. She has no elementary classroom experience, but has worked with elementary teachers in the past. She may be an important resource in the future for assisting Harder and Clay with establishing K–12 coordination of the program and facilitating understanding and support for the program in the central office.

RESOURCES AND SUPPORT

Funding

A key element of a program's sustainability is the extent to which the district steps in to assume program costs that had previously been supported by outside funds. In 1998–1999, GCSP funding included a mix of district and federal Eisenhower funds, as well as remaining LSC funds. Since then, the district has continued to support the science materials center, and has used its Eisenhower funds to support one teacher expert (Harder) and district funds to support the other (Clay). Many administrators expressed their pride in the district's deep level of commitment to the elementary science program. The assistant superintendent for instruction remarked that it was rare to have anything better than "maintenance"-level support given the BSD budget cuts. "We made a very strong commitment" to the science program, she said.

Past cuts to the science program during the downturn in local industry demonstrate its vulnerability under district financial constraints, and many signs point to this being a significant concern in the future. As the cost of education has increased due to inflation and a growing student population, the local tax contribution to education has not kept apace, increasing just under 10 percent between 1991–92 and 2000–01. At the same time, the state has increased the demands it makes on the district by way of increasing accountability for student performance (see section on Accountability below). Additionally, the new teacher contract, which provides for the first salary increases in seven years, will require an additional $58 million over the next three years.

The administration began cost cutting measures in the last budget cycle that included the proposed elimination or reduction of the curriculum department, where science program leaders reside. Ultimately, the curriculum department was not included in the several million dollar cut, but it was decided that a general review of the department would be done in 2001–02. One objective of the review will be to determine whether and how the structure and functioning of the administration could be made more efficient. This turn of events illustrates the vulnerability of the program, even in the presence of strong district support.

Seeking external grants is not without its costs and challenges.

Accessing External Funds Through Grant Writing

As the LSC project has shown, outside funding can contribute greatly to program development and ultimate sustainability. However, seeking external grants is not without its costs and challenges. In the BSD, anyone is free to seek external funds. The district's only grantwriter focuses her efforts on large federal grants. There is no formal process for making decisions about which grants to pursue based on alignment with district goals. Rather, the grantwriter explains, "I look for the opportunities within the district and I match them with the external opportunities." In many ways, this approach has served the district well. With help from various program leaders with initiative, drive, and skill, she has raised about $40 million over the past 12 years for much needed support.

However, according to the director of elementary education and the grantwriter, there are some risks associated with bringing in large grants. They suggest that large grants could be a potential trap because of the cost of maintaining an initiative when the seed money for development goes away. The director of elementary education suggests that external funds should be sought with caution, so that initiatives begun will have support for follow-through.

An additional illustration of the "double-edged" sword of successful fundraising relates to perceptions of the program and its endurance. Specifically, on the positive side, the district has been very successful at bringing in external funds to support the science program. Unfortunately, such success can potentially lull district and community members into a false sense of security about education funding and undermine efforts to increase public support for education.

Further, according to the grantwriter, success of implementation and sustainability of a funded program is "largely a function of who is running the grant...their intelligence, imagination, credibility, vigor, network of colleagues. And their ability to be in touch with principals and also with the community is a major factor." Additionally, she suggests that a large project requires a large effort and, presumably, a significant change in the way some aspects of the district function. However, the BSD educators are, in general, highly reluctant to change, and resistance to do so has taken many forms ranging from quiet discomfort to aggressive acts of sabotage. Therefore, a program leader's skill in navigating these potential pitfalls is a prerequisite for the success of a grant-funded project or program.

Community and Partnerships

In the early years, the local community played a significant role in establishing and developing the elementary science program. Partnerships with local environmental organizations were key assets during North's tenure, offering content expertise as well as moral support. These connections to the community have remained, although they are less intense today. For example, during the LSC period program leaders developed a referral list of local scientists who were available to consult with teachers and/or contribute to classroom work, and teachers do indeed use this resource. Several local environmental and science organizations also have developed program offerings that correspond to the science kits, and some provide space for training sessions and offer a range of experiential programs to the schools in the district. Finally, many of the BSD's parents are involved in science or environmental-related work or recreation and, as a result, they seem to appreciate the science curriculum.

ACCOUNTABILITY

Accountability for Student Performance

State-Level Standards and Assessment: Over the past several years, Bolton, like other places in the country, has increased accountability measures at both the local and state level. As in other states, the focus of accountability centers on student achievement in reading and mathematics. Science is not tested, and in the face of pressure to improve student performance on achievement tests in reading and mathematics, science instruction in the classroom often recedes.

Bolton, like other places in the country, has increased accountability measures at both the local and state level.

The State Board of Education recently mandated that each local district adopt the state's content and performance standards in reading, writing, and math. It also mandated that all children should be independent readers by the third grade. In response, the BSD approved its own, more rigorous standards. Science content standards had also been approved, but as of April 2001, the science performance standards were "caught in a political mess." If tests are developed for science and/or social studies, the director of assessment predicts that they will be implemented in the eighth grade. Bolton also has elected to add the science component of the CAT to its portfolio, even though it is not aligned to the science curriculum. It is unclear what effect the presence of data on science achievement would have on the status of GCSP. For the near term, the importance of science will not be elevated by a state test.[7]

Additional accountability measures are placing considerable pressure on the elementary principals and teachers who will be held responsible for their students' rate of improvement. For example, the State Department of Education is beginning to issue school report cards primarily based on achievement scores on the state tests. The accomplishments of Bolton schools, including test scores, are carefully tracked and published each year in the *Tracking Performance Guide,* an extensive document of more than 500 pages. Although the initiative for increased accountability is still in development, the message of teacher and administrator responsibility is clear.

"We could end up overly focused on reading, writing, and arithmetic."

As the LSC wound down, the director of assessment and evaluation was instructed to shift focus from science to reading. She, with the director of curriculum evaluation, expressed concerns that, "we could end up overly focused on reading, writing, and arithmetic." In fact, a review of the 1999–2000 *Tracking Performance Guide* reveals a significant emphasis on outcomes in reading, language arts, and mathematics while relatively little information is given on the CAT scores in science. Many teachers commented that only standardized tests in science and social studies with high stakes attached would guarantee airtime for them in the classroom. One teacher referred to the climate as a "testing sickness of politicians."

7 At least three tests will be given in BSD each year; and beginning in grade three, a child will be tested using one of them every year until she completes the 10th grade. Two of them are new and based on the state standards. The Standards Tests are administered in grades 3, 6, and 8, and the Graduation Requirement Test (GRT) is administered in the 10th grade. The Standards Tests are intended to provide information on student's progress through the grades, and the GRT was meant to be used as an exit exam beginning in spring 2002. As of April 2001, however, there were several bills before the legislature calling this purpose into question. The third test, the California Achievement Test in reading, writing, and math, has been in use all along. Now it will be given in a more comprehensive form to students in grades 4, 5, 7, and 9.

District-Level Accountability Measures: The BSD's capacity to pursue its own curriculum-driven assessment has been curtailed as a result of the state's assessment program. Since the state has increased its role in testing, the BSD's Department of Assessment and Evaluation has reduced its size and scope. Over the course of the 1999–2000 and 2000–2001 school years, its budget was cut by 45 percent with a corresponding cut in staff. There are no district-level tests in place as of 2000–01. Moreover, if curriculum coordinators want to improve their program's assessment tools, they would have to contract with someone outside the district as the department can no longer provide that expertise internally.

Accountability for Teaching Science

It is no wonder that time to spend on science is at a premium and that it is increasingly difficult to ensure that it is taught. In the absence of a student test, no other formal mechanisms (such as the mandatory observation principals make of mathematics and reading instruction) exist to monitor the quality and quantity of the science instruction. A principal might opt to watch a lesson or a teacher might ask that she be observed, but in either case, the personal commitment of a teacher or principal is the deciding factor. In the survey, when asked who would notice if they didn't teach science, teachers' most common response was either "my students" or "the parents," and not "my principal." In fact, while nearly all of the principals responding to the survey reported that they actively support science teaching, less than half of the responding teachers felt their principals did so. The impact of a perceived lack of support from their building administrators, particularly when other subjects compete for their time, leaves teachers open to the possibility of foregoing science instruction.

Time to spend on science is at a premium and that it is increasingly difficult to ensure that it is taught.

The commitment of teachers and principals to teaching science is extremely variable. Although the extensive training provided via LSC funds went a long way to address teacher reluctance, it still remains a problem. Furthermore, although it is common knowledge that there are resistant teachers and principals across the district, program leaders are unable to discern the magnitude of the problem. This lack of awareness is due to several factors. First, the GCSP does not have the resources to maintain firsthand knowledge of the quantity or quality of science instruction that takes place in schools. The two teacher experts, Harder and Clay, cannot visit enough classrooms in the 60 elementary schools to say with any confidence that they have an accurate account of the status of the program as it is being delivered. And, although the clerks at the science materials center see for themselves how thoroughly a kit has been used when it is returned, this information is not captured and used at this point. The new program leaders are aware of this information gap and are interested in addressing it in the coming years.

Central office administrators have a lack of concrete knowledge of the status of the program.

Central office administrators also have a lack of concrete knowledge of the status of the program. They generally believe that the LSC funds did their job: to address the issue of teachers' and principals' discomfort with the science kits by providing them with an extensive amount of high quality training. Now that the project is complete, they expect that science is being taught. Rather than put mechanisms in place to ensure that this is the case, administrators appear for the most part to be satisfied with the assumption that all is proceeding smoothly.

Several principals, teachers, and administrators see promise in the availability of the district science standards as a tool for accountability. They are commonly accepted as stating the minimum requirement for science. Thus, if a teacher is not using GCSP, the board-adopted science program, a principal could ask that teacher how they are teaching their students the science standards. Whether principals are asking these questions is unknown. One high level administrator reflected, "You have to have principals that are going to be willing to hold those teachers accountable and, when they need help, pick up the phone and call Sophia or Maria and say, 'I need help.' They have to be willing to do that and a lot of principals aren't..."

There is no way to guarantee that all the teachers who need training on a kit actually attend the training sessions.

Another stumbling block to ensuring science instruction is the voluntary nature of training for new teachers. Central office administrators were pleased that the district chose to fund the teacher expert positions (Harder and Clay) that had previously been supported by LSC funds, and felt that this was a strong step toward ensuring that training for new teachers would continue. However, there still is no way to guarantee that all the teachers who need training on a kit actually attend the training sessions. Many teachers believe that the only guarantee that all students will receive science is the presence of a standardized test in science that is of equal importance to the tests in reading and mathematics.

EQUAL ACCESS TO SCIENCE

As explained above, teachers motivated to do so can avoid teaching the kits, and when this happens, the children in those classrooms simply did not receive science instruction. The problem of uneven student engagement in science lessons explains in large part the interest that GCSP leaders have in the *Kagan Cooperative Learning Project*. Program leaders view Kagan as a way to broaden teacher willingness to take on science as well as enhance student engagement. Kagan's varied learning structures are designed to ensure that all students in a classroom participate while at the same time managing the nature of participation so that it is organized and controlled. In general, teachers involved in the Kagan program report a greater sense of control as well as a greater degree of student engagement that can translate to more widespread, authentic involvement with the science lessons.

ANALYSIS

The story of elementary science in Bolton is, like any district program, complex. Many factors have contributed to and inhibited its sustainability over time. These factors fall into three general categories:

1) factors that pertain to the surrounding conditions-these describe the influences of the context in which the program operates;

2) factors that pertain to the science program components-these describe the role that concrete elements of the science programs (e.g., curriculum, professional development, leadership) have in contributing to or inhibiting sustainability; and

3) factors that pertain to the whole science program-these describe overarching contributors to and inhibitors of sustainability that affect the program in less tangible but still powerful ways.

These factors do not operate in isolation. They interact with each other, and shift in importance and influence over time. Factors that were particularly striking and pertinent in Bolton are discussed below. For an in-depth discussion of all of the factors, see the cross-site report of this study[8].

Factors that Pertain to Science Program Components

Accountability: Missing Information

The pressure to produce high ratings on standardized tests in language arts and math is intense. Beginning in the third grade, children are tested annually and their teachers and principals are held publicly accountable for their performance. Teachers, principals, and central office administrators all agreed that class time will continue to be focused on preparation for testing as long as the public pressure exists. Without a comparably important test in science that would elevate its importance, time for science has and will continue to be seriously reduced.

Without an important test in science that would elevate its importance, time for science has and will continue to be seriously reduced.

Further, no measures exist to demonstrate whether GCSP is actually used in classrooms. Even in the program's heyday, program leaders thought that as high as one-third of the teaching staff were not teaching the program. The BSD has limited and mostly informal mechanisms for knowing when and to what extent the program is in use. Without accurate information, program leaders have only anecdotal information and their own perceptions on which to make strategic, programmatic decisions.

8 The Executive Summary of the Cross-Site Report can be found in Appendix E.

A combination of factors fosters this lack of accountability. First, science program leaders in Bolton have no formal authority over teachers and principals; their influence over others is primarily a function of their personal relationships. Second, while principals do possess authority to address instructional issues, they rarely do so on behalf of science. Their supervisor, the executive director of elementary education, has numerous other priorities and has taken little action to urge principals to give more attention to science. And third, as a result of the long-standing administrative support for the program, many assume that the program is in operation as planned and that there is no need for further efforts to assess its status.

Science program leaders influence over others is primarily a function of their personal relationships.

Leadership: Shifting Styles With Changing Leaders

Several aspects of leadership have affected Bolton's science program over time. Foremost were the styles and skills of the program leaders. North's persuasive style and vision enabled the program, with all of the associated components, to take root at a time when hands-on science was a revolutionary idea. After the use of kits was accepted and the materials center was in place, the program needed to be refined in order to mature. Parson's abilities and vision enabled her to lead the redesign of the curriculum, make the materials center more efficient, and pay much-needed attention to teachers' professional development and their assessment of student learning. Now, Harder and Clay are focusing on integrating the curriculum and on deepening teachers' knowledge of inquiry to help the program adapt to current and emerging needs and priorities.

The superintendents over the years also have played important leadership roles in the development of the science program. In the early years, Bolton's superintendents gave North tremendous support that was highly visible, directing funds and other resources in her direction. Other superintendents were less involved, with some reducing the program's resources and thus the program itself. In all cases, the effect of their actions had an impact on the program's status. Now, like their predecessors, Harder and Clay make strategic leadership decisions in light of their superintendent's attitudes and accessibility.

Principals, although courted by the program leaders, have had minimal engagement with the science program. Teacher leaders, on the other hand, have had significant positive impact on the science program at many different points in time.

Principals, although courted by the program leaders, have had minimal engagement with the science program. Except for their early involvement in the science committee and in the first seven pilot schools, they have, by and large, chosen to focus on other aspects of their role as educational leaders in their buildings. To the degree that their attention encourages teachers to provide science, their lack of attention has enabled reluctant teachers to avoid providing the program.

Teacher leaders, on the other hand, have had significant positive impact on the science program at many different points in time. A consistent theme has been the use of teacher experts who have been vital to the program in their assistance to classroom teachers. Additionally, by focusing on the development of their own professional knowledge, they have built the district's institutional understanding of science education trends.

Indeed, Harder and Clay are now focusing on developing a new cadre of teacher leaders to help support the next phase of the program. And yet, they must recognize the limitations imposed on what teacher leaders can do. For example, the fact that they only assist classroom teachers when invited has positive and negative effects. On the positive side, their energy and expertise is spent on assisting teachers who are anxious to improve their practice rather than on teachers who are indifferent. On the negative side, however, the teachers who are most likely to request their help are the ones who are in need of it the least. The chances for teacher leaders to improve the practice of reluctant teachers are minimal because those teachers rarely invite them to do so.

Even though barriers prevented them from acting as program leaders had hoped, SSCs provide support through communicating about their own belief in and commitment to the science program.

The use of SSCs as supports for improved instruction at the building level has not played out as intended, but still has born fruit. Instead of serving as a local resource for improving instruction, these teachers have been more occupied with performing clerical duties, such as ensuring that the kits are ordered and circulated. While the professional development invested in these teachers did not result in the kinds of activity intended, it did have an unintended positive effect in achieving "buy-in" from the participating teachers. Thus, even though organizational or cultural barriers prevented them from acting as program leaders had hoped, SSCs provide support through communicating about their own belief in and commitment to the science program.

Instructional Materials: Perfecting the System

The development and revision of kits has been a strength of Bolton's science program over time. North began by identifying commercially available kits with the intent that they would serve as models for locally produced ones. Revisions that took place in the ensuing years were built on the feedback of teachers who used them and involved years of planning and testing. The result is a set of instructional materials that reflects the district's own thinking, rather than ideas imported from elsewhere. The sense of ownership of the kits and the close identity that the district has with the science program seem to be at least, in part, a result of this history.

The science materials center is a source of pride for the district's administration.

Management of kits is complicated and essential to the program's success and survival. It requires processes for selection, distribution, storage, collection, and refurbishment that are efficient and reliable. When kit delivery mechanisms were poorly organized and arrival of kits less predictable, some teachers were frustrated and dissatisfied with the program. Parson put a great deal of effort into improving the materials management processes and her efforts were recognized and applauded by the teachers.

Now, the science materials center is a source of pride for the district's administration. It was consistently spoken of as a symbol of the district's commitment to the science program and was consistently funded, even in the midst of budgetary cutbacks. The materials center seems to contribute to the sustainability of the program by providing administrators with the evidence they need to feel confident in the program's strength and endurance.

Professional Development: Supporting Shared Understanding

Professional development has contributed to establishing and enriching the program throughout its evolution. Professional development targeting resource teachers and teacher leaders has been a consistent program aim, and has served the program's long-term needs in several important ways. First, it ensured that there was a cadre of teachers who understood, practiced, and advocated for inquiry-based pedagogy. In turn, program leaders relied on these teachers to be advocates for and participants in program development steps, such as kit and curriculum revisions. Moreover, they lent credibility to the program. Although one cannot know if the high level of professional development the teacher leaders and resource teachers received led to changes in classroom instruction, it is clear that it did, in fact, improve the quality of the program's curriculum, structure, and shared vision.

Professional development also focused on teachers' use of the kits, particularly during the LSC period when mandatory kit training took place on a massive scale. While the degree to which this training affected classroom practice is not clear, it did have a powerful effect on teachers' knowledge of the program, its intent, and delivery. This shared knowledge is, in itself, important for sustainability because it establishes a common understanding of the program's goals and expectations for how they would be achieved districtwide. In the absence of LSC funds, kit training for teachers new to the BSD or new to a grade is now voluntary and much less well-attended. As a result, as teachers leave the district, the challenge of maintaining that level of awareness is significant.

Factors that Pertain to the Whole Science Program

Perception: Incomplete Information

Bolton is one of the oldest elementary, kit-based science programs in the nation. Having such a long past in which the district has identified with the use of kits seems to reinforce its continued investment in them. This is evident in each curriculum review cycle during which the commitment to the kits is reaffirmed with little or no debate. Even now, when adherence to

The program's history is a matter of pride to the district.

state standards has elicited concern about kit-based curricula in other districts, Bolton has not seemed to waver. The district identifies itself as a place where hands-on science is taught and, with each challenge, that identity has been strengthened.

Further, the program's history is a matter of pride to the district, and its emergence as a national leader in science education is an essential part of its self image. North played a large role in this development as an influential person who built status for herself at the same time that she was building the reputation of the district. She is described as an energetic pioneer who brought national attention to the innovative program in Bolton. The long history supporting the collectively held "self-image" of the district when it comes to science reinforces sustainability since deviating from that identity seems less and less likely as time passes.

The perception of the science program within the district has had powerful effects on its evolution. It is important to note, however, that oftentimes the perception of the program is not based in concrete knowledge of its status. That information eludes program leaders and administrators, albeit for different reasons.

For example, limited time and resources makes it difficult, if not impossible, for leaders to stay informed about the actual status of classroom practice across the district. Although leaders have access to classrooms, they only go where invited, and only a small percentage of the district's 1,300 certified elementary staff make such requests. Thus, the leaders must rely on a relatively small sample of teachers for their understanding of the overall program status, giving them a truncated understanding of its true status, strengths, and weaknesses. As a result, program leaders make decisions about professional development, for example, based on their perception of need, which is necessarily a product of incomplete information.

The notion of imperfect information about the science program is not confined to its leaders. Interviews with central office administrators suggested that their understanding of its status is also limited. Instead, administrators tend to make assumptions about the status of the program based on the amount of resources that are directed to it. The frequent response to questions like, "What happens when science isn't taught?" was incredulity. Administrators know that the purpose of the LSC was to train all of the teachers to teach the kits, and now that the project is over, they assume that teachers are indeed teaching science.

Adaptation: Responding to District Conditions

The Bolton science program could not have endured for 30 years without making significant adaptations in response to the many changes that took place in the district. Examples are plentiful: The BSD revised the kits in response to the regular curriculum review cycle; leaders trained teachers in the use of Kagan Cooperative Learning Strategies as a proactive attempt to help them address the difficulties inherent in using science kits; and leaders developed a science leadership cadre, after the LSC funds had been exhausted, as a strategy to continue the momentum of professional development and provide additional human resources to a program that was experiencing the loss of funds.

Program leaders can be successful because they are responsive to district conditions.

North's and Parson's two different strategies for leading the program are powerful examples of the ways in which program leaders can be successful because they are responsive to district conditions. North was concerned with establishing the use of kits in the district, and this meant enticing teachers to use the unfamiliar materials. Her strategy was to start small, with volunteer teachers in seven willing schools, and to grow the program gradually. Parson, on the other hand, was concerned with introducing a more structured curriculum with uniformity across the district. The use of kits was already familiar to teachers; she wanted them to use different kits in a structured sequence. Her strategy was to devise mandatory training that left teachers with no choice about participation. Both strategies were successful because they were appropriate and responsive to the contexts and conditions of the time.

Philosophy: Committing to Hands-On

The firmly held belief in Bolton that science should be taught through the use of hands-on materials has already been described in terms of its positive influence on sustainability. Besides making a direct contribution, this commitment to hands-on instruction has also had an indirect effect by creating a hospitable environment in which other programs with a hands-on approach can grow. The *Kagan Cooperative Learning Program* is a case in point. The *Kagan Program*, brought to Bolton by Parson, has flourished, and as it has spread to other curricula, it has reinforced the district's belief in hands-on teaching. As evidence of the value of hands-on instruction builds, it strengthens the sustainability of all hands-on programs.

It is hard to imagine a place that could be more committed to teaching science using a hands-on approach, but that commitment alone doesn't guarantee that science will be taught.

Another aspect of philosophy that has had a significant but sometimes discouraging influence on the program's endurance is a belief in the importance of teaching science at all. While many teachers and principals report that they believe in teaching science, the absence of any accountability for doing so implies that it is less important than other subjects for which there is accountability. In fact, over its long history, the science program has seen serious contractions in the face of tight budgets and pressure from standardized tests in language arts and mathematics. It is hard to imagine a place that could be more committed to teaching science using a hands-on approach, but that commitment alone doesn't guarantee that science will be taught.

SUMMARY

Bolton School District's current program is the natural and obvious descendent of the previous generations of elementary science. The outstanding trait that they all share is perhaps not really a feature of the programs themselves, but of the school district and larger Bolton community in which they are embedded. That trait is an abiding commitment to having children use materials to study science, and it is striking to note how firmly the district identifies its elementary science program with the use of science kits and the science materials center. The long history of the program shows that there have been periods when the program waxed and waned. The district's strong commitment to kits has helped the program take advantage of opportunities to expand, but it has not protected the program from feeling the effects of shocks, be they budgetary , teacher turnover, or a focus on other subject areas. The BSD will never be immune to unpredicted, dramatic, far-reaching events, but its past experience with survival during turbulent times is instructive. Only with hindsight over such a long period of time can one understand the unpredicted and subtle aspects of the program's sustainability.